

Plasma Heating: An Advanced Technology

Systems that provide extremely high temperatures for industrial processing exemplify spinoff aids to industrial productivity and manufacturing technology

In 1958 NASA embarked on a program to put man in space, a task of myriad challenges for the technology of that day. Among the many formidable problems to be overcome was the matter of protecting astronauts from the high friction temperatures they would encounter as their spacecraft reentered the atmosphere at very high velocities. NASA's solution was the ablative heat shield, composed of a material that was designed to burn off as the spacecraft plunged into the atmosphere; the burning dissipated much of the heat energy, with the result that the astronauts' cabin usually got no hotter than 80 degrees Fahrenheit even though friction temperatures ran well over 2000 degrees for the Mercury and Gemini Earth-orbiting capsules and as much as 5000 degrees when the Apollo Command Module hurtled Earthward after a lunar mission.

In developing the initial Mercury heat shield, and refining the design for the greater demands of the Apollo spacecraft, NASA faced a problem. The heat shield materials had to be tested and verified on Earth before committing the spacecraft to flight test. But how do you generate temperatures of 5000 degrees or more? That was the big question for the members of a NASA team assembled at Ames Research Center and charged with the important task of developing a Re-entry Heating Simulator to prove the effectiveness of heat shield materials. The answer, discovered only after exhaustive testing of many different heat sources, was plasma heating, which involves passing a strong electric current through a rarefied gas to create a plasma — ionized gas — that produces an intensely hot flame. This technique allows generation of temperatures far greater than those that can be generated by conventional oxygen combustion heaters, temperatures as high as 20,000 degrees Fahrenheit.

With the help of industry firms, NASA designed modern plasma arc heaters and exposed heat shield materials in the laboratory to temperatures well above those they would encounter during an actual reentry. Plasma heating technology made the Ames Re-entry Heating Simulator a reality and, in a sense, made possible American manned space flight.

Plasma heating, however, was not a NASA invention. The concept had been around since 1878, although it never found wide usage, and it was still in limited use in European industrial activities when Ames was developing the simulator. But NASA's research spurred a revival of interest in the decades-old technology and influenced a dramatic post-Apollo growth in use of advanced plasma torch systems for industrial processing. NASA's work thus stimulated a stagnant technology and expanded the market for plasma heating systems; some of the NASA technology found its way into the new types of plasma arc torches developed in the 1970s and 1980s.



An example is Plasma Technology Corporation (PTC), Raleigh, North Carolina, a company whose whole product line is based on the NASA technology. PTC scientist Salvador L. "Bud" Camacho was a member of the Ames Research Center team that developed the Re-entry Heating Simulator in the 1960s. He subsequently left NASA, founded — in 1971 — a predecessor company that evolved into PTC, and used his NASA-acquired technological expertise as a departure point for developing a line of plasma torches and other equipment for industrial and research applications. PTC is now a well-established firm with an impressive list of customers in the U.S., Canada, Japan and several European nations.

Camacho sees further growth in industrial use of plasma heating systems because, he says, they "are among the most effective means for efficiently generating heat. They far surpass conventional methods because they offer greater temperature control, greater processing control, faster reaction time, lower capital costs and more efficient use of energy."

"The real benefits of plasma heating are just coming into focus," Camacho adds, suggesting that the technology might find even greater applicability in environmental applications than it has in industrial use. For example, the extraordinary temperatures available from plasma torches permit safe disposal of many types of toxic wastes by pyrolysis, the decomposition of hydrocarbons by the application of intense heat; municipal wastes are primarily hydrocarbons and plasma heating could convert them to harmless gases that could be recovered and used for fuel. The technology offers similar potential for disposing of medical wastes or for preventing the heavy metals in incinerator ash from leaching into underground water sources by vitrifying them, converting them into a glassy, rocklike substance that does not leach into soil.

Salvador Camacho and colleague Dr. Louis J. Circeo, formerly with Georgia Tech Research Institute and now with PTC, are engaged in demonstrating a number of advanced applications of plasma heating technology, including pyrolysis/vitrification of contaminated wastes. They have contracted with the Army Corps of Engineers for demonstrations involving destruction of hazardous asbestos wastes being removed from government buildings; plasma torching melts the asbestos fibers, which are subsequently solidified into a chemically inert, non-hazardous solid material. Camacho and Circeo are additionally negotiating projects that will demonstrate plasma heating procedures for the disposal of chemical weapons, dangerous chemicals and radioactive waste.



At Chapparell Steel, Midlothian, Texas, plasma torch technology enables a "mini-mill" (above) to produce specialized steel in small batches, a competitive advantage. Below, Dr. Salvatore L. Camacho demonstrates use of a plasma torch; his company and its whole product line are based on NASA plasma torch technology.

